DOUBLE-FRONT DETONATION OF HETEROGENEOUS EXPLOSIVE MIXTURES

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Energetic metal particles contained in a condensed explosive can result in a two-event heterogeneous explosion, in which the explosive detonates first and the combustible particles react with the gaseous detonation products and air later. The secondary event can involve a variety of combustion modes as a result of mixing, dispersion and the interaction between the gas reaction and the additional physical processes involved in the mass, momentum and heat transfer between the particles and the gas. It remains unknown if a "double-shockfront" detonation wave can exist as one of the combustion modes of this event, despite a few laboratory studies indicating some features of such a detonation structure in aluminum particles suspended in a reactive gas mixture. The theory of the double-front detonation has yet to be thoroughly studied and also remains an open research area. The present paper presents our recent experimental and theoretical results in an attempt to search for a solution to these problems. Experiments have been carried out in a horizontal detonation tube of 8 cm internal diameter. The facility was made from Schedule 160 steel pipe and consists of a 10 m test section and a 3 m relief section. The test section was equipped with a dispersion system that enables aluminum dust to be suspended in a gaseous mixture. The initiation pulse was produced by detonators whose mass is close to the value of the critical initiation charge, or a 2 m detonation driver that exceeds the critical initiation. Pressure histories along the tube length and detonation cell size were measured. Figure 1 shows a pressure history indicating a double-front detonation structure with the addition of aluminum particles in comparison with a single-front pressure history obtained from the host gas mixture alone. Figure 2 displays the corresponding detonation cellular structure recorded by smoke foil technology. Conditions for the existence and steadiness of such a double-front detonation structure were investigated in a range of initiation energies, particle sizes and concentrations, and oxidant compositions of the host gas detonation products, in an attempt to correlate the critical values of the secondary heat and its release rate with the double-front structure parameters. Theoretical and numerical studies were also conducted, both in laboratory scale and free-field conditions, to try to identify the propagation mechanisms of various detonation modes and their critical conditions related to the secondary heat and its release rate.

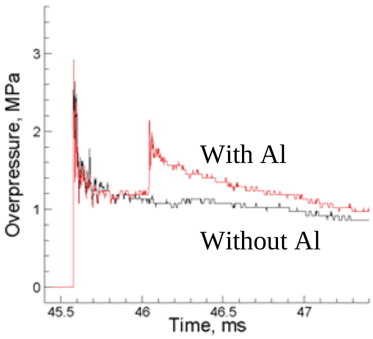

Figure 1: Double-front detonation

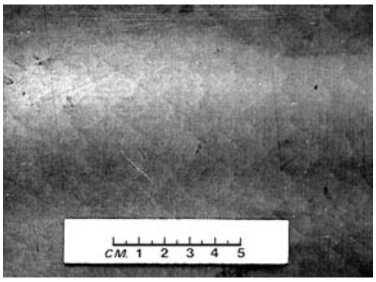

Figure 2: Double-front detonation cellular structure